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Is Vaping Related to Other Health Risk Behaviors Among Adolescents?

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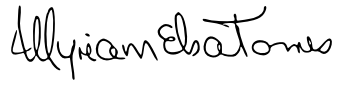
Approved



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Thesis Summary:

Vaping (smoking a vaporized liquid with an active ingredient) has had an upward trend in high school populations (ages 13-18) within the last decade, mainly due to misinformation and targeting from companies that sell e-cigarettes (142, 7). The most common substances that are vaped in teens are nicotine and tetrahydrocannabinol (THC, the active ingredient in marijuana) (147). Nicotine and THC bind to NAchR and CB1 receptors that affect certain parts of the dopamine reward pathway, such as the prefrontal cortex, the ventral tegmental area, and the ventral striatum in the brain (44,106). Dysfunction within these pathways have been associated with an increase of impulsivity, which is linked to high risk behaviors (39). There also have been studies directly connecting nicotine usage and THC usage with impulsivity. Thus, we hypothesize that vaping these substances will have a positive association with high risk behaviors linked with impulsivity. Using the 2017 Youth Risk Behavior Surveillance System (YRBSS) survey, analyses were conducted to assess whether there is an association between vaping and impulsive high-risk behaviors such as hazardous driving, sexual practices, and violence among high school students. We found that the prevalence of e-cigarette use was about 13% within the general high school population reported. Furthermore, we discovered a strong association between vaping and the health risk behaviors listed above. For example, teens who reported vaping were 8.5 times as likely to drive while drunk, 14.3 times as likely to use heroin, and 3.9 times as likely to get into a physical fight. Males were more likely to report vaping (OR for female vaper was .678 with a CI of .6107-.7528), but Hispanics/Latinos were less likely to do so (.8013 OR with .7057-.9099). Additionally, teens reported to either have vaped once recently (36.6% from the population that vaped), or currently vape daily (16.3% from the population that

vaped), indicating the quick progression of addiction. With this information, future public health interventions can focus on specific at-risk populations.

Introduction

Vaping (also known as smoking e-cigarettes) has been a popular aid for smoking cessation, becoming widespread in the United States from 2006 (141). However, from 2009 onwards, vaping has exponentially gained popularity among middle schoolers and high schoolers over 13%, to the extent that the Food and Drug Administration (FDA) has called it an epidemic (FDA, 140, 142, 145). Studies show that over 11.1% of teens in the US have vaped at least one day in the past 30 days in 2017 (128). This is a worrying number as it is similar to the percentage of teens who reported smoking cigarettes in 1988 (15.7%), which marked the start of an increase in teen smoking during the 1990s (129-130). This has already started to show with teens, as surveys show that in 2019, 28.5% of high schoolers reported current e-cigarette use (144). Demographically speaking, according to a study, males and females were comparable in use, but black high schoolers were less likely to vape than white or Hispanic students (145).

E-Cigarette Components

E-cigarettes (also known as vape pens) are a new delivery system of substances in aerosol (2). A vape cartridge (or pod) containing a psychoactive ingredient and flavoring agents is attached to a heating agent that vaporizes the product with propylene glycol (2). The amount of nicotine in the vape pod widely varies from company to company and can be customized to the amount that a person wants (143). Although nicotine is the official chemical for medical use, many drugs can also be vaped. Some examples that are being used now are nicotine, tetrahydrocannabinol (THC), synthetic marijuana such as K2 and Spice, dimethyltryptamine, Flakka, and more. There is a booming business industry for vape pens and accessories, the most popular being JUUL labs. Additionally, there is a more underground business for vape pods with different chemicals, oftentimes with exported products from China. One of the most notorious is

Dank Vapes, which has been associated with the outbreak of mysterious lung illnesses leading in lung collapse (CDC). They also sell liquid nicotine, so you can make your own e-liquids at whatever strength you want (e-cig express).

Access to Teens

Although vape pens were initially made for adults who were quitting smoking, teens have ended up with a skewed perception of vaping through tailored ad campaigns and promotional material targeting the youth population on multiple social media platforms (such as YouTube, Instagram, and twitter) (7). Celebrities promote e-cigarettes, such as on shows like David Letterman, as well as TV and cartoon advertisements, which state that vaping is a safe alternative to smoking (6). A study done on the websites of e-cigarettes show that 73% of sites show images of "modernity," 44% for increased social status, and 32% for enhanced social activity (7). They also repeat that the e-cigarettes produce only "harmless water vapor" (a claim that is wildly inaccurate), and that they are more convenient than cigarettes by circumventing smoking laws (7). In particular, a representative for JUUL went to a school for a presentation, where he stated that JUUL "was much safer than cigarettes" and that "FDA would approve it any day". This same representative recommended that a student should refer his nicotine addicted friend to JUUL (8). Additionally, on their website, JUUL says that "[JUUL's] simple and convenient system incorporates temperature regulation to heat nicotine liquid and deliver smokers the satisfaction that they want without the combustion and the harm associated with it," clearly trying to give a false image of harmlessness (8).Vaping has also infiltrated the meme culture, with pages like Buzzfeed collecting memes about vaping from across the internet (12). All of these ads across different platforms are trying to sell an image of e-cigarettes being a harmless alternative to smoking, while still keeping the glamorous and social aspect.

JUUL has additionally made their product appealing to adolescents through the high nicotine content, discreet shape, and different flavors, such as Chocolate Treat, Cherry Crush, and Snappin' Apple (9). A recent study has shown that these flavors play a big role in teen usage (124). The statistics of the social media of JUUL were analyzed in another study, showing that there is a very high social media presence with emphasis on younger models portraying the JUULS in a trendy way (10). The majority of people that follow the JUUL twitter account are teens, so this message is clearly hitting the intended target (10). There have also been similarities to tobacco smoking advertising, with a focus on the pleasure, romance, flavors, style, and satisfaction rather than as a medical aid (11). These ad campaigns have been significantly successful, as there has been a significant increase from 2018 to 2019 in students that vape: 1 in 4 students in 12th grade, 1 in 5 in 10th grade, and 1 in 11 in 8th grade. (14). Additionally, 21% of high school students reported using e-cigs in the past 30 days in 2018, but only 3% of adults partook, showing the wide disparity between use in teens and adults, the intended population (15-16). The rates have gotten so bad that the FDA has had to get involved multiple times by trying to find companies that provide access to minors, as well as JUUL for their marketing campaigns (1, 8, 19).

As more teens vape, a form of a vape culture has started to form (148). The ease of access to the e-cigarettes, as well as the lack of stigma when vaping rather than cigarette smoking has allowed for nicotine consumption without judgement (148). When interviewed about the appeal of vaping, adolescent vapers have reported that in addition to the e-cigarette being discreet and easy to use, there is also a risqué element for the that makes them look cool (17). The creation of this vape culture then feeds money back into the e-cigarette corporations, who continue to use

the ad strategies to target even more teens, creating a feedback loop that will result in higher vape usage.

Studies have also shown that teens whose first nicotine product was an e-cigarette were more likely to start smoking cigarettes within 2 years, a concerning statistic as vape usage in teens rise (18). This highlights the clear pathway to smoking that e-cigarettes are providing, rather than helping people quit smoking. As 90% of adult smokers started before the age of 18, this could cause a spike in cigarette smoking yet again. Although there are many different chemicals that can and have been vaped by teens, the most common active ingredients that are vaped are nicotine (30%) and THC (13.1%) (147,146). Additionally, 1 in 4 students who had used vape pens and marijuana in their life reported vaping THC (146).

How do Nicotine and THC affect the mind?

Nicotine is an alkaloid plant toxin found in tobacco and is the chief addictive ingredient for cigarettes (33). Nicotine enters the bloodstream through the lungs and circulatory system after being inhaled (either through a vape or through a cigarette) (34). This allows the nicotine to activate the numerous fast neuronal ionotropic cationic nicotinic receptors (nAChRs) in multiple regions of the brain (42, 2, 34,28, 43, 54). nAChRs have 5 subunits, with the a4B2 and a6 receptors being the most predominant for brain pathways that influence the dopamine reward pathway (55). The reward pathway essentially connects good behaviors with the pleasure that we feel and rewires our brain to prefer doing these activities in order to get more of the good feeling. This dopamine system specifically is comprised of dopaminergic neurons in the VTA that connects to the medial prefrontal cortex and ventral striatum, which consists of the nucleus accumbens and the olfactory bulb (57, 60, 76). Unsurprisingly, this brain system is very influential in any addiction, as the brain almost fixates on that one activity for the main source of

pleasure. In order to trigger the reward pathways, the NAchR receptors are involved in the binding of an chemical (normally acetylcholine, but also nicotine) to a receptor (44). The triggering of these receptors increases the electrochemical reactions through calcium and sodium voltage gated channels, amplifying signals causing the release of glutamate (an excitatory neurotransmitter) over GABA (an inhibitory neurotransmitter), which then causes the signal from the NAchR to override other signals and release DA into the VTA (34, 72, 78, 89). This release in dopamine in the VTA is connected to an positive response in the reward pathway, reinforcing the behavior (42). Additionally, a few studies associate the NAchRs in the VTA with an increase of DA release in the ventral striatum (nucleus accumbens), another part of this pathway (23, 43).

Once vaped, THC uses the same mechanisms as nicotine to get to the brain. The main receptor that THC binds are G protein coupled cannabinoid receptors (CB1), whose natural chemical is anandamide, but THC can also bind to it (105, 120, 122). CB1 is expressed in multiple areas throughout the brain, such as the hippocampus, cerebellum, basal ganglia, and nucleus accumbens (also involved with the reward pathway and have been associated with multiple systems, including limbic systems through mRNA localization studies (106, 121). It has been found to be a mostly presynaptic receptor, with studies looking at neuronal specific locations found that CB1 is colocalized with D1/D2 receptors in the striatum (121). Withdrawal from THC causes a loss of dendritic connections in the nucleus accumbens, and reduction in dopamine cell activity in rat studies (107-108).

Connection of Impulsivity to Nicotine and THC

This dopamine reward pathway within the brain also regulates impulsive behaviors. Impulsivity is defined as “actions that are poorly conceived, prematurely expressed, unduly risky

or inappropriate to the situation and that often result in undesirable consequences," through a lack of "executive control" and inhibition/shifting of behaviors based on information (20-21). Another common definition is "a predisposition toward rapid, unplanned reactions to internal and external stimuli without regard for the negative consequences of these reactions to themselves or others" (22). Adolescence is a particularly increased time of impulsivity and risk taking, and teens are particularly vulnerable to addiction (25). The teenage brain is easily molded throughout the years, being affected by nutritional status, environment, status in life, and drugs/alcohol (69). Although the brain is at its largest volume by 10.5 for girls and 14.5 for boys, neuroanatomical changes happen throughout adolescence (70). Impulsive sensation seeking (ISS) is shown as very common in teens and young adults and can lead to risky behaviors and unsafe locations (62, 23). One major sub-component of the ISS is the motivation-reward pathway, which would explain why impulsive decisions are made when there is a positive emotional state towards a pleasure activity (also known as positive urgency) (62). This positive urgency, as well as sensation seeking, has also been connected to risky behaviors such as gambling, drinking, illegal drug use, and sexual behaviors (63, 64, 65).

Some specific tests that examine impulsive behaviors include reward-choice paradigms, where smaller but faster rewards are better than long term rewards, and response disinhibition/attentional paradigms, where impulsivity forces you to make premature choices (22). Impaired inhibition is another frequent measure of impulsivity with drug abuse, through the use of go/no-go tests, stop signal reaction time (SSRT), and five-choice serial reaction time (5CSRT) (24). The go/no-go test gets test subjects to execute or inhibit a response, testing for the impulse to go forward with the response (24). The SSRT test gets the subjects to inhibit a response they already started, and the 5CSRT task tests for suppressing responses until a

stimulus tells them to proceed (24). The performance on the go/no-go and the SSRT tasks is positively correlated in control groups, indicating a similar effect (25). Another exam to test for ISS is the UPPS-P Impulsive Behavior scale, which tests for lack of planning, perseverance, sensation seeking, and urgency (62). The Barratt Impulsiveness Scale (BIS) also tests for ISS through measures for non-attention and non-planning (62).

Some studies have pinpointed locations in the brain that are affected by nicotine and THC that increase impulsivity. In general, the incorrect release of DA throughout the reward system can cause altered reinforcement processes and delay gradient, causing excessive impulsive decision making based on recent stimuli versus incentive motivation (39, 49). This would cause quick actions that bring more pleasure to be favored, even if it may not be the best decision overall. Artificial stimulation of the high affinity nAChR receptors in the VTA leading to the medial prefrontal cortex have been associated with impulsivity (23). Dysfunction in the medial prefrontal cortex has also been implicated in smokers, with smokers scoring higher on tasks testing for impulsivity for smokers (30). There have also been studies associating the NAchR receptors in the VTA with an increase of DA release in the ventral striatum (nucleus accumbens), which has shown an increase in impulsive behaviors (23, 43). NAchR A6 receptors particularly have been implicated with the increased release of DA in the striatum (56). The abnormal DA stimulant properties affecting D1 and D2 receptors in the nucleus accumbens shell has been particularly implicated for the reward reaction (58). This may be because stimulating too much of the D1 DA receptor can disrupt the function of the medial prefrontal cortex (23).

There have also been teen-specific effects with nicotine on growing brain regions. A study looking at adolescent rats versus juvenile and adult rats reveals that adolescents have higher levels of D1 receptors than in the juveniles/adults, which could cause an increase in

addictive behaviors and impulsivity during those years (85). This has been shown by another study where adolescent rats do not require as much drugs to make the dopamine association (86). Another study giving nicotine to adolescent rats resulted in additional neuroanatomical and gene expression changes in the VTA for adolescents, causing extensive interaction networks that could contribute to dependence and heightened effects (72). Studies with nicotine addicted periadolescent rats versus adult rats shows more chronic direct effects of nicotine usage specifically with changes of subunits expressed for NAchRs that deal with increased nicotine effects within the ventral midbrain (where the VTA is located) (96). There is an increased amount of a6 subunit of NAchRs within the peri adolescent rats, which has caused an increased ability to release DA into the nucleus accumbens and has a role in increasing the potency by turning nicotine into a full agonist (96, 97). This is also shown by another study that blocked the stimulant effect of nicotine when the expression of the a6 unit was blocked (98). Another study using nicotine addicted adolescent rats showed significantly increased amount of receptors in the midbrain with long lasting effects past a month after they stopped the use of the drug (99), and another showed an increase of D1 and D2 receptors and decreased serotonin receptors in the peri adolescent rats only (100). These changes have shown deficits with cognitive performance in adulthood, especially with impulsivity and attentional performance (101).

Neuroimaging studies done on brains that had been given an acute amount of THC revealed decreased blood flow to the medial prefrontal cortex, and increased brain metabolism in the reward pathway controlling the impulsivity (149). Additionally, a study with rats treated with the natural chemical for CB1 receptors regarding decision making in a maze showed poor decision-making skills (150).

Multiple studies have specifically connected the increase of impulsivity with general nicotine and THC usage. Animal studies show nicotine by injection leads to an increase in impulsive behaviors (23). A study with smokers shows increased impulsivity in smokers than nonsmokers through an impulsivity test gauging participants' value for increased delayed money and cigarettes versus immediate access (52). Another study used a mixture of behavioral tasks and personality questionnaires to exhibit the increased impulsivity in smokers (53). Additionally, studies show tobacco smokers show an increase in impulsive behaviors, where nicotine is the addictive ingredient (23).

THC usage has also been associated with increased impulsivity through multiple impulsive responding tasks (66, 67). Inhibitory processes were also impaired at a certain level of marijuana intoxication through a study with individuals at different levels of marijuana intoxication answering questions regarding risk taking behaviors (119). Additionally, the perception of smoking THC caused an increase in impulsivity through multiple tasks, which is relevant because people who vape can still be affected (67). Heavy marijuana users showed majorly increased impulsivity through tests measuring impulse control when given THC (68). A study looking at risk scale scores between regular marijuana users versus non-users found significantly higher scores for the marijuana users (108). Another study using data from the Mental Health Supplement to the Ontario Health Survey regarding negative consequences (that involve risk taking behaviors such as driving accidents and arrests) with marijuana smoking have found a high dose-consequence relationship (109). Early adolescent marijuana use has also been connected to later risk related problems, such as drug abuse (110,111) Increased THC usage during early and middle adolescence has been associated with risky sexual behaviors such as having multiple sexual partners, not practicing safe sex, drinking or using drugs before having

sex (110, 112, 113, 114). Marijuana is also the most common drug that drivers arrested for reckless driving tested for, which is concerning because the areas impaired by it are heavily involved with driving, such as coordination, perception, and vigilance (115-116). Multiple studies that simulate driving and flying show increased risky behavior and decision making, indicating more impulsivity (117,118). Additionally, impulsivity has been strongly associated with general drug abuse. Preclinical studies on animals have shown an increase of impulsivity when they were given free access to drugs, causing more acute long-term effects of the drug (Ahmed and Koob, 1998, 1999). There have also been some chronic effects of regular use of THC. One study showed an increase in errors in attentional tasks and cognitive functioning in a population of young adults (103). There have also been links in cognitive deficits in long term THC users and schizophrenia (104).

However, there are not many studies out directly associating vaping with impulsivity and high risk behaviors, other than one study out very recently connecting vaping with mental health disorders, illicit drug use, and impulsivity in university students (151).

Specific hypothesis

Vaping (nicotine and THC) is associated with high risk behaviors in younger generations due to an increase in impulsivity.

Methods

Study Sample

The YRBSS was first administered in 1990 in order to monitor high risk behaviors in youth - spanning from violence, sexual behaviors, drug and alcohol use, tobacco use, dietary behaviors, and physical activity (125). The survey is administered to high school students in public and

private high schools every two years during the spring semester (125). Students are chosen by random selection of a period (e.g. 1st period) or a specific class (e.g. all math classes) (125). This survey has data from 1991-2017 with over 3.8 million responses in a 3 stage cluster sample design (125). The content of the YRBS has stayed mostly the same, with some minor tweaks from time to time to decrease bias and update questions to the current times (125). These results are compiled into datasets, which are available for the public to download in SAS or SPSS syntax. For 2017's survey, there were 90 questions, 75% of the schools chosen took part in the sample, with 81% of students in the schools sending in questionnaires (125).

Measures

SAS 9.4 was used to run frequency tests on the YRBS 2017 data (freely accessible online) to look at prevalence of high-risk behaviors and vaping, as well as calculate Odds Ratios between vaping and high-risk behaviors.

E-Cigarette, Cigarette, and Marijuana Use

There were 3 questions used to test for usage of cigarettes, vapes, and marijuana: questions 33, 36, and 49 respectively (full questions and answers shown in Table 1). These questions were used to assess the frequency of use within the population. They were also used for constructing odds ratios for vaping and high-risk behaviors.

Impulsive Behaviors

25 questions were used to test for separate high-risk behaviors, separated into 4 main categories of: driving safety, sexual activity, drug use, and violence. The specific questions are shown in Table 1. These questions were used to assess the frequency of these behaviors, as well as constructing odds ratios with the questions mentioned above for vaping and high-risk behaviors.

Results

Population Demographics

The amount of responses recorded for the entire survey was 14,765. The main statistics used to gauge the population are age, sex, and race (questions 1, 2, 4, 5 shown in Table 1). Around 75% of the participants were between the age of 15-17 (shown in Table 2). A big majority of the students were white (43.49%), with only 19.38% who were black and 25% that were Hispanic/Latino. All the other ethnicities recorded only made up 11.94% of recorded responses. There was an even amount of males (51.41%) and females (48.59%) recorded.

Prevalence of Use

The prevalence of use for all three substances (vapes, cigarettes, and marijuana) were all in the minority (< 20%). However, more people smoked marijuana (19.7%) than cigarettes (8.49%) or vaping (12.97%), as shown in Table 3. Something else interesting to note is that a vast majority of the people who recorded that they vaped only vaped once or twice (36.6% of the yes population). This also holds true for cigarette smoking (34.6%), and marijuana smoking (34.9%). However, the next majority of students ended up smoking every day (or often), with 16.3% of the vaping population who vaped daily, 20.6% who smoked daily, and 18.7% who smoked marijuana over 40 times in the past 30 days.

Prevalence of Impulsive Behaviors

All of the impulsive behaviors were very much in the minority for the general population, all under 45%. The average of the percentages of people who would do at least one impulsive behavior listed is 12.66%.

The average of percentages for impulsivity in driving safety is 15.89%, with texting while driving (37.32%) being the most common, as shown in Table 4. Substance related driving safety

(driving or having a driver under the influence) had an average of 11.91%. An interesting trend that seemed to form is that with most of the questions, the percentage of students who do an impulsive activity once or twice is highest, but the next highest percentage is the students who do the activity the most. For example, 42.6% of students who rode with a driver who drank alcohol went one time, but 17.6% rode 4 or more times.

Violence, as gauged with the questions about getting into fights, within this population was much less common, with an average of 7.685%, and within the people who got into a fight, most of them fought once (shown in Table 5).

The average percentage of students who took part in some form of drug use was 7.73%. Drinking alcohol (28.96%) was the most common behavior within this category, and 12.96% binge drank within the last 30 days, shown in Table 6. Other substance use without the alcohol had an average of 5.33%, the least common of all of the types of impulsive behaviors. There is a similar trend of students doing the impulsive behavior either once or twice or almost daily with substance abuse. For example, 16.4% of cocaine users and 25.2% of methamphetamine users used 40 or more times in the past 30 days.

The most common of all of these behaviors within the population are the impulsive behaviors associated with sex with an average of 24.2%. As shown in Table 7, sexual activity at some point of life (28.53%) was relatively common, but the percentage of using versus not using a condom during the last sexual encounter was almost equal (yes 54.38% no 45.62%). One risky behavior that was extremely common among the whole population was the lack of use of birth control pills before sex (81.59%).

Prevalence of Descriptive Statistics/Behaviors with Vaping

The odds ratios (OR) and 95% confidence intervals (CI) of the relationships between selected variables and e-cigarette use is shown in Table 8. Females were less likely than males to vape (the OR for females is .678 with a 95% CI of .6107, .7528). Additionally, people who were Hispanic/Latino were less likely to vape (.8013 OR with a 95% CI of .7057, .9099).

All of the associations between the presence of impulsive behaviors and vaping were statistically significantly positive, with the exception of condom use (OR .9117, 95% CI .6907, .9540). Students who vape were on average 5.632 times as likely to engage in an impulsive behavior in the driving safety category, 3.715 times as likely in the violence category, 12.2 times as likely in the drug abuse category, and 3.19 times as likely in the sexual activity category. Driving under the influence had higher ORs (8.54 for alcohol, 9.34 for marijuana). Additionally, almost all of the drug abuse had ORs > 10, with using smokeless tobacco (21.74) and smoking cigars (23.78) being > 20.

Discussion

General Population Statistics

The race distribution within the teen population shown in this study has a similar spread to other studies, such as data from Human Resources and Services Administration (HRSA) in 2014 that showed almost half of the New York teen population were white, 23% were Latinx, and 16% were black (127). The study also accurately reflects the general US population distribution for males and females, as the 2017 US Census shows the teen population is 51% female and 49% male (126). The prevalence of vaping in teens in 2017 (12.9%) also mirrors

other studies done in 2017 (11.1%) (128). These findings affirm that there is a representative population in the 2017 YRBS data in all categories.

Unsurprisingly, the high-risk behaviors were overwhelmingly in the minority. There were also other studies that showed similar results to this study for the impulsive behavior. For example, within driving safety, other studies also showed around 90% of teens who wore seat belts (131). Additionally, a study in the National Center for Health Statistics showed similar (~30%) percentages of current sexual health for teenagers (28.53% for YRBS 2017 data). However, when it came to general drug abuse, the National Center for Drug Abuse statistics showed a higher rate of general drug abuse (11.5% between 10th and 12th graders) (134). However, when looking at studies on specific substances, such as smokeless tobacco (3.5%) and opioids (9.5%), there are similarities to the 2017 YRBS data (5.04% and 14.14% respectively) (135).

An interesting note regarding the frequency of use for the substances as well as the impulsive behaviors is that there was generally an increase of students who did the activity frequently, even if a majority of the students only did the activity once. For example, 36.6% of the vaping population vaped only once or twice but 16.3% of the vaping population vaped daily (as mentioned in the Results). This could indicate that these behaviors and substances are highly habit-forming where infrequent use could lead to addictive use.

Odds Ratios Statistics

Almost every single one of the impulsive behaviors had a positive association with vaping, and quite a few had overwhelmingly high odds ratios, supporting the hypothesis and previous literature on the effects of nicotine and THC on the mind. This could indicate that vaping is connected with impulsive behaviors - either as a marker or as an effector.

Drug abuse had the highest odds, with some of the ORs >20 (average 12.2). The highest odds dealt with other forms of tobacco, such as smokeless tobacco (21.74) and cigars (23.7806), highlighting the potential relapse from e-cigarettes to tobacco or potentially cigarettes. This matches literature research that showed that teens who started were more likely to start smoking in 2 years (18). There were still high odds for hard drugs, such as cocaine (13.4094), methamphetamines (13.1412), ecstasy (13.6523), and heroin (14.3189). This is concerning as these drugs cause a physical addiction, which is even harder to quit from. This is also shown in the literature, as studies show that nicotine addiction can lead to chemical and molecular changes in the brain that could lead to drug abuse (139). This also could contribute to the higher ORs for drunk driving (8.5416) and driving under the influence of marijuana (9.3435). These results are worrying, as an increase in vaping could backtrack the progress in lowering drug abuse in teens (135). Additionally, over 38% of deaths have been caused by drunk driving, which could increase due to more vaping in teens (132).

In the sexual activity category, the highest OR was in the amount of sexual partners a person had. However, one surprising result was the condom use - people who vape were more likely to use a condom than non-users. This, in conjunction with the general population statistic that showed an equal amount of people who used and didn't use condoms, shows that it is much more widespread.

Strengths/weaknesses of results

One of the major strengths of this research is the data being used. The YRBS is an official survey released by the CDC directly with a large sample size. Additionally, the population spread, and behavior statistics match other studies done during the same year, which only strengthens it further.

However, there were a lot of limitations to the study. Firstly, the test that we used was a very simple frequency table, and there are a lot of other variables that were not adjusted for, such as socioeconomic status. This study is purely a comparison study, with the assumption that high risk behaviors were due to increased impulsivity rather than testing through tasks that gauge impulsivity directly. There is also no way to differentiate what substance the teens in the study were vaping (it could even be just flavoring). Additionally, this study is a self-reported survey, which has been known to not be as accurate due to biased responses, although there is a very high response rate (136). Even so, this survey was only administered to public and private schools, so there is an entire section of the homeschooled population that are being left out.

Recommendations/future research

This study only hits the tip of the iceberg of this increasingly worrisome public health issue. Firstly, surveys could be administered that specify substances that are being vaped (such as nicotine or THC), which might reveal some differences between the effect of certain active ingredients. Some of the weaknesses with the variables that were not adjusted for could be addressed in future studies. There are also not a lot of studies on the demographics of vaping, and some studies that could focus on location (east v west coast, urban v rural areas) as well as race could be administered. Another potential topic that could be explored more is the changes in these impulsive behaviors over time through the YRBS study from anytime in 2011-2017, replicating studies like this one to see if any changes happened as vaping increased. There should also be some more research into the connection between vaping and drug abuse, as there were such high odds (and potentially narrowing the vaping to vaping specific psychoactive drugs). Some studies could be done with potential validation of responses regarding drug abuse, especially as survey self-reports tend have some bias (136). Additionally, with the recent lung

problems that have started to show up in teens who have vaped, there very well may have been a decrease in the amount of teens who vape; it would be interesting to see if the rates of impulsive behaviors would be affected if that happened - or if cigarette smoking went up as a result of people trying to quit vaping.

Another major topic that was mentioned in many studies was the connection between vaping and cigarettes. One study uses the 2015 YRBS data to show how dual use of cigarettes and vaping were the most prone to do high risk behaviors (137). However, more focus into the relationship between cigarette smoking and vaping should be highlighted, as not only could vaping lead to higher relapses into cigarette smoking (the very thing it was aiming to stop), but it could lead to a more concerning combination of the two substances.

Another potential interesting idea could look into the perception of vaping in teen populations now in conjunction with cigarette smoking, to see if the problematic message the companies are sending out are still being heeded.

In a more biological standpoint, more research could be done regarding vaping specifically with certain tests of impulsivity, like the ones mentioned above. Additionally, MRI scans could be performed on teens that vape to see the specific changes that could occur from frequent usage, potentially similar to this study dealing with brain scans of marijuana smokers (138).

Any research into e-cigarette usage is beneficial for narrowing populations that can be targeted for vaping ads, as well as tailoring e-cigarette quitting programs, as well as general drug programs for vapers. Additionally, with the spread of reputable data in an easy to access format, teens can get a clearer picture of the danger that the corporations have been trying to hide this whole time.

Tables

Table 1: Questions Used in the YRBS

#	Question	Answer choices	Variable Tested
1	How old are you?	12 years or younger 13 years old 14 years old 15 years old 16 years old 17 years old 18 years old or older	Age
2	What is your sex?	Female Male	Sex
4	Are you Hispanic or Latino	Yes No	Race
5	What is your race?	American Indian or Alaska Native Asian Black or African American Native Hawaiian or Other Pacific Islander White	Race
8	How often do you wear a seatbelt when riding in a car driven by someone else?	Never Rarely Sometimes Most of the time Always	Risk behavior: Driving Safety
9	During the past 20 days, how many times did you ride in a car or other vehicle driven by someone who had been drinking alcohol?	0 times 1 time 2 or 3 times 4 or 5 times 6 or more times	Risk Behavior: Driving Safety

10	During the past 30 days, how many times did you drive a car or other vehicle when you had been drinking alcohol?	I did not drive a car or other vehicle during the past 30 days 0 times 1 time 2 or 3 times 4 or 5 times 6 or more times	Risk Behavior: Driving Safety
11	During the past 30 days, how many times did you drive a car or other vehicle when you had been using marijuana (also called grass, pot, or weed)?	I did not drive a car or other vehicle during the past 30 days 0 times 1 time 2 or 3 times 4 or 5 times 6 or more times	Risk Behavior: Driving Safety
12	During the past 30 days, on how many days did you text or email while driving a car or other vehicle?	I did not drive a car or other vehicle during the past 30 days 0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 to 29 days All 30 days	Risk Behavior: Driving Safety
18	During the past 12 months, how many times were you in a physical fight?	0 times 1 time 2 or 3 times 4 or 5 times 6 or 7 times 8 or 9 times 10 or 11 times 12 or more times	Risk Behavior: Violence

19	During the past 12 months, how many times were you in a physical fight on school property?	0 times 1 time 2 or 3 times 4 or 5 times 6 or 7 times 8 or 9 times 10 or 11 times 12 or more times	Risk Behavior: Violence
33	During the past 30 days, on how many days did you smoke cigarettes?	0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 to 29 days All 30 days	Cigarette Smoking
36	During the past 30 days, on how many days did you use an electronic vapor product?	0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 to 29 days All 30 days	Electronic Vapor Product Smoking (Vaping)
38	During the past 30 days, on how many days did you use chewing tobacco, snuff, dip, snus, or dissolvable tobacco products, such as Redman, Levi Garrett, Beechnut, Skoal, Skoal Bandits, Copenhagen, Camel Snus, Marlboro Snus, General Snus, Ariva, Stonewall, or Camel Orbs? (Do not count any electronic vapor products)	0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 to 29 days All 30 days	Risk Behavior: Drug Abuse
39	During the past 30 days, on how many days did you smoke cigars, cigarillos, or little cigars?	0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 to 29 days All 30 days	Risk Behavior: Drug Abuse

43	During the past 30 days, on how many days did you have at least one drink of alcohol?	0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 to 29 days All 30 days	Risk Behavior: Drug Abuse
45	During the past 30 days, on how many days did you have 4 or more drinks of alcohol in a row (if you are female) or 5 or more drinks of alcohol in a row (if you are male)?	0 days 1 or 2 days 3 to 5 days 6 to 9 days 10 to 19 days 20 or more days	Risk Behavior: Drug Abuse
49	During the past 30 days, how many times did you use marijuana?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Marijuana Use
50	During your life, how many times have you used any form of cocaine, including powder, crack, or freebase?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
51	During your life, how many times have you sniffed glue, breathed the contents of aerosol spray cans, or inhaled any paints or sprays to get high?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
52	During your life, how many times have you used heroin (also called smack, junk, or China White)?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse

53	During your life, how many times have you methamphetamines (also called speed, crystal, crank, or ice)?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
54	During your life, how many times have you used ecstasy (also called MDMA)?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
55	During your life, how many times have you used hallucinogenic drugs, such as LSD, acid, PCP, angel dust, mescaline, or mushrooms?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
56	During your life, how many times have you used synthetic marijuana (also called K2, Spice, fake weed, King Kong, Yucatan Fire, Skunk, or Moon Rocks)?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
57	During your life, how many times have you taken steroid pills or shots without a doctor’s prescription?	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse
58	During your life, how many times have you taken prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it? (Count drugs such as codeine, Vicodin, OxyContin, Hydrocodone, and Percocet.)	0 times 1 or 2 times 3 to 9 times 10 to 19 times 20 to 39 times 40 or more times	Risk Behavior: Drug Abuse

59	During your life, how many times have you used a needle to inject any illegal drug into your body?	0 times 1 time 2 or more times	Risk Behavior: Drug Abuse
63	During your life, with how many people have you had sexual intercourse?	I have never had sexual intercourse 1 person 2 people 3 people 4 people 5 people 6 or more people	Risk Behavior: Sexual Behaviors
64	During the past 3 months, with how many people did you have sexual intercourse?	I have never had sexual intercourse I have had sexual intercourse, but not during the past 3 months 1 person 2 people 3 people 4 people 5 people 6 or more people	Risk Behavior: Sexual Behaviors
65	Did you drink alcohol or use drugs before you had sexual intercourse the last time?	I have never had sexual intercourse Yes No	Risk Behavior: Sexual Behaviors
66	The last time you had sexual intercourse, did you or your partner use a condom?	I have never had sexual intercourse Yes No	Risk Behavior: Sexual Behaviors

67	The last time you had sexual intercourse, what one method did you or your partner use to prevent pregnancy? (Select only one response.)	I have never had sexual intercourse No method was used to prevent pregnancy Birth Control Pills Condoms An IUD (such as Mirena or ParaGard) or Implant (such as Implanon or Nexplanon) A shot (such as Depo-Provera), patch (such as Ortho Evra), or birth control ring (such as NuvaRing) Withdrawal or some other method Not sure	Risk Behavior: Sexual Behaviors

Descriptive Tables of Questions Used:

Table 2: Demographic Characteristics of the 2017 YRBS participants

Characteristic	N	%
Age		
Younger than 12	59	.4
13	22	.15
14	1922	13.09
15	3586	24.42
16	3688	25.12
17	3611	24.59
18+	1796	12.23
Missing	81	-

Sex		
Male	7112	51.41
Female	7526	48.59
Missing	127	-
Hispanic/Latino		
Yes	3653	25.18
No	10857	74.82
Missing	225	-
Race/Ethnicity		
Am Indian/Alaska Native	137	.95
Asian	648	4.49
Black/African American	2796	19.38
Native Hawaiian/Other PI	116	.80
White	6261	43.49
Hispanic/Latino	1543	10.69
Multiple - Hispanic	2104	14.58
Multiple - Non-Hispanic	823	5.70
Missing	337	-

Table 3: Prevalence of Vaping, Cigarette Smoking, and Marijuana Smoking

Characteristic	N	%
Vaping		
0 days	11178	87.03
1 or 2 days	610	4.75
3-5 days	304	2.37
6-9 days	190	1.48
10-19 days	175	1.36
20-29 days	114	.89
All 30 days	273	2.13
Missing	1921	-
Yes	1666	12.97
No	11178	87.03

Cigarette Usage		
0 days	13184	91.51
1 or 2 days	424	2.94
3-5 days	199	1.38
6-9 days	138	.96
10-19 days	129	.9
20-29 days	80	.56
All 30 days	253	1.76
Missing	358	-
Yes	1223	8.49
No	13184	91.51
Marijuana Usage		
0 times	11520	80.08
1 or 2 times	1002	6.97
3-9 times	730	5.07
10-19 times	331	2.30
20-39 times	266	1.85
40 or more times	537	3.73
Missing	379	-
Yes	2866	19.92
No	11520	80.08

Table 4: Driving Safety

Characteristic	N	%
Seat Belt		
Never	238	2.00
Rarely	520	4.38
Sometimes	1196	10.07
Most of the time	3174	26.73
Always	6746	56.81
Missing	2891	-
Yes	758	6.38
No	11116	93.62

Riding with a Driver who drank Alcohol		
0 times	12290	83.52
1 time	1034	7.03
2-3 times	781	5.31
4-5 times	181	1.23
6 or more times	429	2.92
Missing	50	-
Yes	2425	16.48
No	12290	83.52
Driving while Drunk		
Did not drive	5627	41.09
0 times	7606	55.54
1 time	226	1.65
2-3 times	125	0.91
4-5 times	26	0.19
6 or more times	85	0.62
Missing	1070	-
Yes	462	5.73
No	7606	94.27
Driving while using Marijuana		
Did not drive	4096	36.39
0 times	6190	55.00
1 time	247	2.19
2-3 times	252	2.24
4-5 times	100	0.89
6 or more times	370	3.29
Missing	3510	-
Yes	969	13.54
No	6190	86.46

Texting and driving		
Did not drive	5632	40.81
0 days	5121	37.10
1 or 2 days	1000	7.25
3-5 days	476	3.45
6-9 days	297	2.15
10-19 days	347	2.51
20-29 days	227	1.64
All 30 days	702	5.09
Missing	963	-
Yes	3049	37.32
No	5121	62.68

Table 5: Violence

Characteristic	N	%
Physical Fighting		
0 times	9239	76.63
1 time	1241	10.29
2-3 times	947	7.85
4-5 times	247	2.05
6-7 times	113	0.94
8-9 times	64	0.53
10-11 times	34	0.28
12 or more times	172	1.43
Missing	2708	-
Yes	758	6.38
No	11116	93.62

Physical Fighting in School		
0 times	13177	91.01
1 time	810	5.59
2-3 times	304	2.10
4-5 times	66	0.46
6-7 times	27	0.19
8-9 times	8	0.06
10-11 times	7	0.05
12 or more times	79	0.55
Missing	287	-
Yes	1301	8.99
No	13177	91.01

Table 6: Drug Abuse

Characteristic	N	%
Smokeless tobacco		
0 days	13742	94.96
1 or 2 days	217	1.50
3-5 days	104	0.72
6-9 days	75	0.52
10-19 days	76	0.53
20-29 days	48	0.33
All 30 days	209	1.44
Missing	294	-
Yes	729	5.04
No	13742	94.96

Cigar		
0 days	13282	92.17
1 or 2 days	456	3.16
3-5 days	227	1.58
6-9 days	153	1.06
10-19 days	95	0.66
20-29 days	46	0.32
All 30 days	152	1.05
Missing	354	-
Yes	1129	7.83
No	13282	92.17
Current Alcohol Use		
0 days	9224	71.04
1 or 2 days	2103	16.20
3-5 days	808	6.22
6-9 days	451	3.47
10-19 days	260	2.00
20-29 days	59	0.45
All 30 days	79	0.61
Missing	1781	-
Yes	3760	28.96
No	9224	71.04
Current Binge Drinking		
0 days	11903	87.04
1 or 2 days	581	4.25
3-5 days	452	3.31
6-9 days	407	2.98
10-19 days	174	1.27
20-29 days	80	0.59
All 30 days	78	0.57
Missing	1090	-
Yes	1772	12.96
No	11903	87.04

Cocaine Use		
0 times	13789	95.04
1-2 times	343	2.36
3-9 times	128	0.88
10-19 times	84	0.58
20-39 times	46	0.32
40 or more times	118	0.81
Missing	257	0.81
Yes	719	4.96
No	13789	95.04
Inhalant Use		
0 times	11197	93.72
1-2 times	382	3.20
3-9 times	157	1.31
10-19 times	67	0.56
20-39 times	46	0.39
40 or more times	98	0.82
Missing	2818	-
Yes	750	6.28
No	11197	93.72
Heroin Use		
0 times	14087	97.96
1-2 times	102	0.71
3-9 times	51	0.35
10-19 times	29	0.20
20-39 times	19	0.13
40 or more times	92	0.64
Missing	385	-
Yes	293	2.04
No	14087	97.96
Methamphetamine Use		
0 times	13994	97.33
1-2 times	150	1.04
3-9 times	67	0.47
10-19 times	43	0.30
20-39 times	27	0.19
40 or more times	97	0.67
Missing	387	-

Yes	384	2.67
No	13994	97.33
Ecstasy Use		
0 times	13761	95.89
1-2 times	302	2.10
3-9 times	117	0.82
10-19 times	62	0.43
20-39 times	25	0.17
40 or more times	84	0.59
Missing	414	-
Yes	590	4.11
No	13761	95.89
Synthetic Marijuana Use		
0 times	13386	93.21
1-2 times	548	3.82
3-9 times	197	1.37
10-19 times	73	0.51
20-39 times	34	0.24
40 or more times	123	0.86
Missing	404	-
Yes	975	6.79
No	13386	93.21
Steroid Use		
0 times	11708	97.02
1-2 times	152	1.26
3-9 times	80	0.66
10-19 times	38	0.31
20-39 times	22	0.18
40 or more times	68	0.56
Missing	2697	-
Yes	360	2.98
No	11708	97.02

Prescription Pain Medication Use		
0 times	12459	85.86
1-2 times	908	6.26
3-9 times	532	3.67
10-19 times	274	1.89
20-39 times	122	0.84
40 or more times	215	1.48
Missing	255	-
Yes	2051	14.14
No	12459	85.86
Illegal injected drug use		
0 times	14065	98.20
1 time	125	0.87
2 or more times	133	0.93
Missing	442	-
Yes	258	1.80
No	14065	98.20

Table 7: Sexual Behaviors

Characteristic	N	%
Current Sexual Activity		
Never had sex	7949	60.78
None during the past 3 months	1398	10.60
1 person	2899	22.17
2 people	433	3.31
3 people	175	1.34
4 people	71	0.54
5 people	25	0.19
6 or more people	129	0.99
Missing	1686	-
Yes	3732	28.53
No	9347	71.47

Multiple Sex Partners		
Never had sex	8039	61.00
1 person	2171	16.47
2 people	1075	8.16
3 people	632	4.80
4 people	380	2.88
5 people	221	1.68
6 or more people	660	5.01
Missing	1587	-
Yes	1261	9.57
No	11917	90.43
Alcohol/drugs and sex		
Never had sex	8017	60.78
Yes	911	6.91
No	4263	32.32
Missing	1574	-
Drank Alcohol before last sexual encounter		
Yes	701	18.89
No	3009	81.11
Condom Use		
Never had sex	8020	61.34
Yes	2931	22.42
No	2123	16.24
Missing	1691	-
Used a Condom during last sexual encounter		
Yes	1973	54.38
No	1655	45.62

Birth Control use		
Never had sex	8026	61.90
No method was used	753	5.81
Birth Control Pills	789	6.08
Condoms	2337	18.02
IUD or implant	176	1.36
Shot/patch/birth control ring	185	1.43
Withdrawal/other method	503	3.88
Not sure	198	1.53
Missing	1798	-
Use of Birth Control pills before last sexual encounter		
Yes	651	18.41
No	2886	81.59

Table 8: Odds Ratios and 95% CI of the Relationship between Selected Variables & Current E-Cigarette Usage

Variable	OR	95% CI
Descriptive Statistics		
Female	.678	.6107-.7528
Hispanic/Latino	.8013	0.7057-0.9099
Driving Safety		
Doesn't wear a seatbelt in a car	3.3910	2.8123-4.088
Rode with a driver who drank alcohol	3.5631	3.1730-4.0011
Drove under the influence of alcohol	8.5416	8.51416-13.3582
Drove under the influence of marijuana	9.3435	7.8907-11.0637
Texted or emailed while driving	3.3362	2.9259-3.8041
Violence		
Was in a physical fight	3.9421	3.4772-4.4691
Was on a physical fight on school property	3.4927	3.0261-4.0312

Drug Use		
Used Smokeless Tobacco	21.7481	18.1317-26.0858
Smoked Cigars	23.7806	20.4812-27.6114
Currently Drank Alcohol	15.853	13.8225-18.1831
Currently were Binge Drinking	15.7914	13.8662-17.9840
Used Cocaine	13.4094	11.2116-16.0380
Used Inhalants	4.1368	3.4422-4.9715
Used Heroin	14.3189	10.7040-19.1545
Used Methamphetamines	13.1412	10.2297-16.8813
Used Ecstasy	13.6523	11.1885-16.6586
Synthetic Marijuana	11.6472	9.9622-13.6172
Used Steroids without a doctor's prescription	8.1998	6.3717-10.5522
Abused Prescription pain medication	5.9175	5.2551-6.6634
Injected any illegal drug	12.8955	9.5686-17.3792
Sexual Activity		
Currently Sexually Active	4.6648	4.1633-5.2266
Had sexual intercourse with 4+ people total	5.3631	4.6585-6.1742
Drank alcohol or used drugs before last sexual encounter	3.7569	3.1022-4.5499
Used a condom during last sexual intercourse	0.8117	0.6907-0.9540
Used birth control pills before last sexual intercourse	1.3747	1.1228-1.6835

OR Ratios and 95% CI for Selected Variables

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